PURDUE UNIVERSITY
Agricultural Experiment Station

BULLETIN NO. 233
JANUARY, 1920

Fig. 1. "Stowell's Evergreen" sweet corn. The ear on the left was taken from a healthy plant. The other ears are of the same age but from stalks affected by the root and stalk rot disease

DISEASE-FREE SWEET CORN SEED

Published by the Station:
LAFAYETTE, INDIANA
U. S. A.

This bulletin summarizes in a brief and popular manner the progress made in 1919 in applying to the improvement of sweet corn the principles and practices recommended in Bulletin No. 224, "Selection of Disease-free Seed Corn," for the improvement of field corn.

It is shown that all the evidence collected indicates that sweet corn for canning, and sweet corn seed stocks can be improved materially by eliminating from the seed stock, ears which are carriers of disease producing organisms. This bulletin, taken in connection with Bulletin No. 224, describes practical methods of sweet corn seed improvement.

The work reported was carried on in association with the Corn Disease Investigations, a project which is organized as a joint undertaking of Purdue University Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, of the United States Department of Agriculture.

This publication should be of special interest to growers and canners of sweet corn and to sweet corn seed producers.

C. G. WOODBURY, Director

DISEASE-FREE SWEET CORN SEED[1]

G. N. HOFFER

Experiments carried on during the season of 1919, show that the yield of sweet corn, whether grown for canning, market, or seed, may be considerably reduced by root and stalk rots affecting the plants. A widespread interest in these experiments has arisen and the purpose of this bulletin is to meet the demand for information relative to the recent developments in these studies.

Previous studies summarized in Bulletin No. 224[2] showed the effect of common organisms which cause rots of the roots, stems and the shanks of corn plants on growth and production. The same kind of study has been extended during the past season to include a number of varieties and strains of sweet corn, with results which are herein briefly reported. Experiments have been conducted wherein seed ears which gave 100 per cent. germination on the germinators but which showed infection by certain harmful organisms, were compared with ears which gave no evidence of being infected. The results have repeatedly shown from 10 to 30 per cent. increase in yield in favor of the apparently disease-free ears.

The methods used to select the sweet corn seed ears were those which have been recommended in Bulletin No. 224. The recommendations for this selection of disease-free seed corn are based upon two fundamental principles: 1—that a healthy normal stalk of an adapted variety of corn will bear a good seed ear, provided no mechanical or frost injury occurs to it; and 2—when it is impossible to select the seed ears from the stalks in the field, they should be physically examined before planting and tested upon the germinator for vitality and freedom from infestation and infection by harmful organisms.

Work was begun on sweet corn in 1918 to determine whether the same recommendations found applicable to dent corn held true for sweet corn varieties as well. In addition to corroborating the work on dent corn, certain facts have developed in connection with the sweet corn work which it is desired to present at this time. The value of physical selection of the seed ears for planting, the curing of the ears immediately after harvesting, and the quality of canned corn as affected by the root, stalk and ear rots are the additional points which will be considered.

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[1] Acknowledgment is hereby made of assistance received from the Horticultural Department, Purdue University Agricultural Experiment Station

[2] Hoffer, G. N., and Holbert, J. R. "Selection of Disease-free Seed Corn." Bulletin No. 224, Purdue University Agricultural Experiment Station, Lafayette, Indiana. September, 1918

ECONOMIC IMPORTANCE OF SWEET CORN

The economic importance of the sweet corn crops can be but grossly estimated. The Bureau of Crop Estimates[1] reports that in 1919 the acreage planted to sweet corn for canning totaled 217,900 acres for the country and that the average yield per acre was 2.2 tons. The total production was 487,319 tons. There were 15,863 acres planted to sweet corn in Indiana in 1919, and the average yield was but 1.2 tons per acre. Indiana ranks tenth in the number of cases of corn packed.

The cost of the seed to plant the acreage for 1919 can be conservatively estimated at $350,000. The chief seed growing regions are in Connecticut, Ohio, Michigan, Illinois, Nebraska and Iowa.

In addition to these figures, it is necessary to refer to the fact that much sweet corn is grown for market, but there are no estimates as to the amount and value of the corn grown for this purpose.

Fig. 2. "Stowell's Evergreen" plot prior to harvesting and grown from disease-free seed ears. Yield, 2.3 tons of corn with husks, per acre. Note good condition of stalks

It is very evident that the chief importance of sweet corn is in its relation as a crop to be canned.

SWEET CORN CANNING PROBLEMS

Two of the chief problems of the sweet corn canners at the present time are: 1—the unprofitable yields or tonnage obtained in many localities, the short crop often being largely due to rots of the roots and stalks of the corn plants; and 2—the reduction in grade of the canned product due to the occurrence of "black," resulting possibly from packing inferior corn.

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[1] Estabrook, L. M. "Weekly Truck Crop News" for October 21, 1919. United States Department of Agriculture, Bureau of Crop Estimates

The first problem is the one which causes the farmers who are growing contract acreages during favorable seasons to ask "What is the trouble with our yields?" Probably the most important factors causing unprofitable tonnage per acre are the rots of the stalks which are so widely prevalent. In many cases the occurrence of these root rots can be traced directly to the quality of the seed used and to the decreasing fertility of many of the fields in which sweet corn is expected to grow.

The second problem is one which is of considerable interest at the present time and which seems to be serious in various localities. To overcome this difficulty will require considerable effort in improving the quality of the seed for growing canning crops.

SYMPTOMS OF ROOT ROTS

The symptoms following the use of poor, infected seed are irregular, uneven stands of corn caused by missing hills where the seed fails to

Fig. 3. "Stowell's Evergreen" corn grown from ears which were infected by organisms causing root and stalk rots. Shows condition of plot just prior to harvesting and of same age as the plot shown in Fig. 2. Both plots were planted in the same field. Yield was at the rate of 1.0 ton of corn with husks, per acre

germinate or the seedling soon dies. When the infected seeds grow, considerable differences occur in the rates of growth of the plants; stunted and barren stalks occur; many stalks will form undersized ears at canning time while the healthy ones will produce normal sized ears. The root disturbances retard the normal development of the plants, and cause a very unevenly maturing crop. This effect of the disease is of special importance because of its probable relation to the quality of the packed corn. It is very desirable that the whole crop should be in the same stage of maturity at canning time.

Other effects of the root and stalk rots are noted in prematurely ripened ears and dead stalks distributed throughout the field. Many of the ears on diseased stalks never get into a good canning condition. The kernels on the ears shrivel and become prematurely dry and worthless for canning.

Summarizing briefly, the effects of the root and stalk rots are seen to lessen production and affect the quality of the corn to be packed:

1. By decreasing the stand;
2. By causing barren stalks;
3. By retarding the normal growth of the stalks so that only nubbins form;
4. By making the maturity of the corn at canning time so irregular that the crop cannot be harvested completely at one, or even two pickings. This results in much loss of tonnage and considerable variations in the quality due to variations in maturity of the corn plucked for canning.

Fig. 4. "Country Gentleman" corn, growing in a poor soil. Note the regular stunting of all of the plants in the thin stand. When infected seeds are planted the stalks vary considerably in their rates of growth (see Fig. 5)

RESULTS OF PLANTING TOO THICKLY

Another consideration which should be given to the disease problem is the effect on the growths of the plants due to overplanting the soil. Every soil has a definite yielding capacity under normal conditions which may vary, however, in the same field. When the soil is overplanted the plants are either predisposed to infection by harmful organisms or actually starved, and as a result are stunted and barren. Those plants which are able to grow will yield little because of the competition with the non-productive plants.

The results of field observations show that serious losses occur, due to planting too many kernels in a hill or planting too close in a drilled row. It is necessary to learn the yielding capacities of the soils used for sweet

corn. In one locality "Stowell's Evergreen" seed may be drilled 12 to 14 inches apart with successful results, while in others it may be necessary to plant the seed 18 to 20 inches apart. The distances for all of the commercial varieties used should be determined by actual experiments repeated for a series of years, so as to eliminate the effects of variable weather conditions on the yielding capacities of the soils and the growths of the plants.

Fig. 5. "Country Gentleman" plants at canning time, which grew from infected seeds. Note the broken shank with a prematurely ripened ear. Both plants are of the same age and grew from kernels on the same mother ear
At right—plants infected by yellow bacteria causing Stewart's Disease. Plants were barren, bluish-green in color, wilted and with drooping tassels characteristic of the disease

EXPERIMENTAL PLOT RESULTS

Experiments which were conducted in 1919 to determine the value of using disease-free seed have given very interesting results. Glenn M. Smith, a pathologist in the investigations of the root and stalk rots of sweet corn, made special field selections of seed ears from apparently disease-free stalks in certain fields in Connecticut during the fall of 1918.

These ears were used in experiments conducted at Bloomington, Illinois, by J. R. Holbert during the summer of 1919. They produced about 23 per cent. more cut corn than the best ears selected from a bulk purchase from the same locality.

Other experiments have given equally interesting results when only home-grown seed was used. The progeny of infected ears was compared in the field with the progeny of those which were shown by the germinator test to be apparently free from the disease. The method used to detect the infected ears is the one which is described in Bulletin No. 224. It consists essentially in examining all of the seedlings from the ears tested by cutting them to see if rots have begun to develop in them. If the seedlings showed the presence of rots on the germinator, the ears were considered to be diseased.

Fig. 6. "Early Evergreen" ears of the same age. The one on the left was taken from a healthy stalk. The other two show premature ripening as a result of the effects of a root and stalk rot of the plants

Another series of experiments at Hoopeston, Illinois, has shown that it may be a profitable procedure to select seed ears for planting on the basis of their physical appearance. The basis for selection was the general appearance of the ears and the freedom of the kernels and cobs from discolorations of various sorts. The ears with deep yellow colored butts and kernel tips and those with cobs badly rotted were suspected of being diseased. By classifying certain seed lots into different grades in this manner, and planting the grades separately in the same field, differences in yield of from 0.1 to 1.5 tons per acre by the grades in each seed lot were obtained.

VALUE OF EAR-ROW STUDIES

Probably the best way to study the effects of the root and stalk rot diseases is to plant all of the kernels from each ear in a row. When the rows are thus planted, the diseases or disease tendencies carried by each of the seed-ears, will become concentrated, each in a separate ear-row and the effects of the diseases will be seen in marked contrasts in the different rows. The ear-row experimental plot is an excellent method to study the yielding power of seed ears and the crop producing capacity of the soil.

In two ear-row plots conducted by G. M. Smith at Ames, Iowa, in cooperation with the Western Grocer Mills, and assisted by R. A. Rudnick of the Iowa State College, the results showed larger yields from the apparently disease-free seed ears. The Iowa-grown "Stowell's Evergreen," the parent ears of which on the germinator produced seedlings free from infection, yielded 13.6 per cent. more than the ears which showed infections in the seedlings, while the plot of disease-free Connecticut-grown "Stowell's Evergreen" yielded 18.3 per cent. more than the same variety, the parent ears of which showed infection.

Fig. 7. The inside of the bases of four "Country Gentleman" stalks. The one on the left, from which most of the roots had been removed grew normally, the other three were stunted plants. Note the discolored joints. These tissues were purplish brown in color

All of the ear-row experiments have shown similar differences ranging from a fraction of 1.0 per cent. to 25 per cent. and more, dependent, in large measure, upon the kind of weather occurring during the growing season. Drought especially reduces the difference in yield between the disease-free and diseased ears. A favorable growing season accentuates the differences markedly.

IMPORTANCE OF USING BEST SEED CORN

Many sweet corn canning companies are beginning experimental investigations on their agricultural problems. Every factory in each locality has its own problems, such as soil types, drainage, fertilizers, development of rotation practices, and determination of the best seed, both as to productivity and quality. Fundamentally, the life of the canning industry is not in the houses and machinery involved; it is in the fertility of the soil in each locality and in the latent powers within the seed planted. It is these latent abilities within the seed which convert the available soil nutrients into the product to be canned. *The kind of seed which is best able to do this work is the disease-free type of the variety grown.* Disease is always a hindering factor, and its effects in the field result in empty cans in the factory at the end of the season.

The recommendations which can be given to canning companies interested in the work are: 1—that varietal experiments should be made to determine the best varieties, both from the standpoint of productivity and quality of the canned product; 2—that rate-of-planting and fertilizer experiments should be made to learn what relation exists between the productivity of the soil and the yielding ability of any particular variety of corn; and 3—ear-to-row plantings should be made, to learn what the yielding abilities and canning qualities of individual ears are when grown under similar conditions.

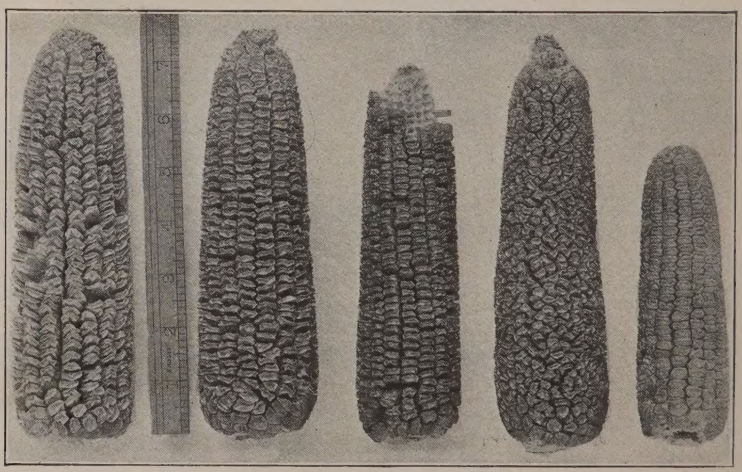

Fig. 8. Good looking disease-free ears of White Evergreen, Stowell's Evergreen, Early Evergreen, Country Gentleman, and Crosby varieties. They are the product of healthy parent stalks and were well cared for during harvest and storage

EFFECT OF DISEASE ON QUALITY OF CANNED CORN

The same organisms which cause the root and stalk rots may infect the kernels on the ears before they are plucked for canning. The kernels are partially rotted and become brown or pinkish in color. This fre-

quently happens after the ears have been damaged by the corn ear worm. These kernels, as well as corn smut, may give rise to undesirable blotches in the packed corn.

It is believed also that the irregular maturation of the ears at the time they are plucked affects the quality of the pack. As has already been indicated, many ears reach the canning condition prematurely, due to infection by root and stalk rot organisms.

The effects of the disease on the development of "black" in the cans is a problem which is at present being investigated.[1]

CONTROL MEASURES

The control of the root rots depends upon proper care in the selection of disease-free seed ears and in preventing the predisposition of young plants to disease in the poorer soils by creating starvation conditions for the plants by overplanting. The best yields are obtained from apparently disease-free seed planted according to the yielding capacity of the soil. Poor methods of farming give diseases their greatest opportunities to develop; therefore, to minimize the effects of disease-producing organisms and to realize the maximum yields from disease-free seed, the soil should be brought into a high state of productivity through proper rotations, intelligent use of fertilizers, and correct planting.

It frequently is impossible to germinate all of the ears which are used for planting the large acreages of some canning companies. It is then a practical procedure to inspect the seed ears for physical defects before planting. The best quality ears naturally are those which conform to the type representative of the variety. They should contain no kernels which are badly discolored. The conditions which weaken the ears from the standpoint of good germination are those which almost always cause discolorations of the kernels. The butts of the ears are frequently badly discolored and the kernels have a dull, lifeless appearance. Such ears can be profitably discarded from the seed stock.

It is believed that the greatest damage to large numbers of seed ears by harmful organisms occurs when the ears are left in the field for long periods after maturity. Seed ears should be selected from healthy, standing stalks in the field soon after they mature and should be thoroughly dried immediately and stored in a well ventilated room. When they remain in the field under the cool moist conditions during the fall, much infection occurs and so long as there is sufficient moisture left in the ears the invasion and infection of the whole ear will continue.

The artificial drying of specially selected seed ears will be studied on a large scale this coming year, but from experiments conducted this season it seems a very practical means of prevention of many seed infections.

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[1] The "black" investigations were made possible by a cooperative arrangement between Purdue University Agricultural Experiment Station and several interested canning companies

RELATION TO OTHER METHODS OF SEED IMPROVEMENT

It is absolutely essential that the seed corn ears used in any system of breeding sweet corn in any locality where its improvement is undertaken, be disease-free and resistant to root and stalk rot troubles.

The method described should be used primarily as a means for mass or bulk improvement. It should precede any effort of the breeder to improve a seed stock, but it is not intended that it should supplant in any way any of the well established methods for sweet corn breeding.

In certain instances where the breeder has not been familiar with the symptoms of the root and stalk rot diseases, difficulty has sometimes arisen through mistaking certain disease effects for normal early maturity. Failure of seed to produce satisfactory field results through disease effects has likewise sometimes been accounted for as an instance of lack of adaptation of the variety.

The best results may be secured when all these factors are interpreted in their proper relations. It is believed that progress in sweet corn improvement may be made equal to that which has been secured in dent corn improvement by properly considering the disease relation.